PicoLAS

FOCUSSING POWER TO THE POINT

User Manual preliminary

Rev. 13.02

PLCS-40

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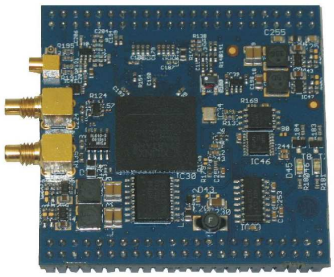
Revision 1301

PLCS-40

Fully digital controlled analog arbitrary pulse generator



- Independent analogue arbitrary function generator
- Freely programmable
- 400 MHz DAC spectrum
- 2 ns ... cw pulse width

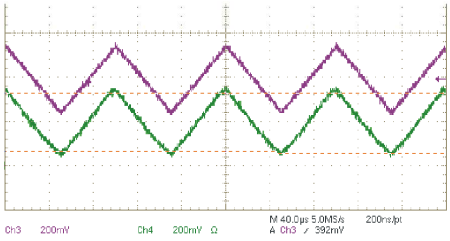


Figure: Analog waveform

Technical Data:*

Outout	2 ns ... cw (10 ns ... 320 ns arbiträry programmable curve shapes)
Data (arbitrary part):	
Analog bandwidth	400 Mhz, 2.5 ns sample rate
DAC Resolution	>100 MHz
Storage capacity	16 bit 515 points of each 16 bit (32 freely programmable curve shapes with max. 128 values at a pulse width of max. 320 ns)
Data (pulse generator):	
Min. pulse width	2 ns
Max. pulse width	cw
Min. repetition rate	1 Hz
Max. repetition rate	200 kHz
Supply voltage	+15 V
Coaxial 50 Ohm output	Generator voltage: 6 V Maximum load: 50 Ω
Trigger Inputs	50 Ω, 5 V, SMC connector 500 Ω, 5 V, 2-Pin connector
Interfaces	PLB-21
Dimensions	61 x 60 x 22 mm
Weight	50 g
Operating temperature	0 to +55 °C

* Technical data is subject to change without further notice.
** See manuals for details.

Product Description:

The PLCS-40 is a freely programmable arbitrary pulse generator (pulsed-AWG).
The internal storage allows to generate up to 32 different freely programmable curve shapes. The maximum repetition rate is 200 kHz.
A very fast 16 bit-DAC generates pulse lengths from 10 ns to 320 ns.

The PLCS-40 is the perfect choice in combination with our laser diode drivers LDP-VRM 005 or BFS-VRM 03.

The pulse generator is offered for those who require specific pulse shapes in order to modulate currents. Pulses with variable rise- and fall times or modified pulse shapes are possible.
Typical applications are driving seed laser diodes or other laserdiodes for materials processing, LIDAR systems, laser communication and rangefinding.

The driver operates from a single +15 V supply voltage.

Optional Accessories: PLB-21
Compatible Products: LDP-VRM 005
BFS-VRM 03

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Description of Connections

The following drawing shows all connections which are available to the user.

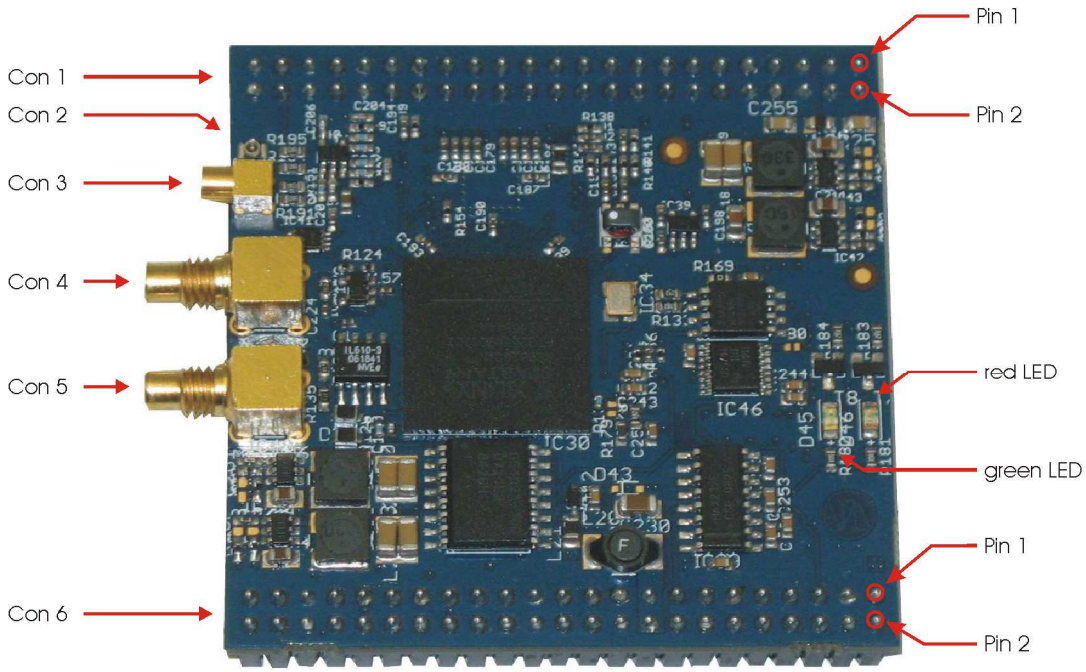

Figure 1: Connectors of the PLCS-40

Connector 1	upper pin header
Connector 2	signal output (not working in current version)
Connector 3	signal output (MMCX connector, not working in current version)
Connector 4	signal output (SMC connector)
Connector 5	trigger input (5V into 50Ohms)
Connector 6	lower pin header

Green LED:

- On: OK
- Off: PLCS-40 not operational

Red LED:

- On: Error
- Off: OK

Connector 1 (upper pin header)		
Pin	**Name**	**description**
1	Vcc (15V)	supply voltage input
2	Vcc (15V)	supply voltage input
3	Vcc (15V)	supply voltage input
4	Vcc (15V)	supply voltage input
5	GND	power ground
6	GND	power ground
7	reserved	do not connect
8	reserved	do not connect
9	reserved	do not connect
10	reserved	do not connect
11	reserved	do not connect
12	reserved	do not connect
13	reserved	do not connect
14	GND	signal ground
15	reserved	do not connect
16	reserved	do not connect
17	n.c.	do not connect
18	n.c.	do not connect
19	n.c.	do not connect
20	n.c.	do not connect
21	n.c.	do not connect
22	n.c.	do not connect
23	n.c.	do not connect
24	n.c.	do not connect
25	n.c.	do not connect
26	n.c.	do not connect
27	TRG_TTL -	trigger input ground
28	TRG_TTL -	trigger input ground
29	TRG_TTL +	trigger input into 500R
30	TRG_TTL +	trigger input into 500R
41	TRG -	trigger input ground
42	TRG -	trigger input ground
43	TRG +	trigger input into 50R
44	TRG +	trigger input into 50R
45	TRG -	trigger input ground
46	TRG -	trigger input ground
47	GND	signal ground
48	GND	signal ground
49	n.c.	do not connect
40	n.c.	do not connect
41	GND	signal ground
42	GND	signal ground
43	signal output	analogue/digital into 50R
44	signal output	analogue/digital into 50R
45	GND	signal ground
46	GND	signal ground

Connector 6 (lower pin header)		
Pin	**Name**	**description**
1	+5 V	output, max 10mA
2	+5 V	output, max 10mA
3	GND	ground
4	GND	ground
5	reserved	do not connect
6	+3,3V	output, max 10mA
7	DA_CH 3	digital-analogue output 3
8	DA_CH 4	digital-analogue output 4
9	DA_CH 1	digital-analogue output 1
10	DA_CH 2	digital-analogue output 2
11	IO 3	digital IO 3
12	IO 4	digital IO 4
13	IO 1	digital IO 1
14	IO 2	digital IO 2
15	RS232_TX	serial connection TxD
16	RS232_RX	serial connection RxD
17	+12V	output, max 50mA
18	+12V	output, max 50mA
19	GND	ground
20	GND	ground
21	AD_CH 3	analogue-digital input 3
22	AD_CH 4	analogue-digital input 4
23	AD_CH 1	analogue-digital input 1
24	AD_CH 2	analogue-digital input 2
25	GND	ground
26	GND	ground
27	reserved	do not connect
28	reserved	do not connect
29	reserved	do not connect
30	reserved	do not connect
41	reserved	do not connect
42	reserved	do not connect
43	reserved	do not connect
44	reserved	do not connect
45	reserved	do not connect
46	reserved	do not connect
47	reserved	do not connect
48	reserved	do not connect
49	reserved	do not connect
40	reserved	do not connect
41	GND	ground
42	GND	ground
43	n.c.	do not connect
44	n.c.	do not connect
45	LED_1	open collector red LED
46	LED_2	open collector green LED

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How to get started

Step #	What to do	Note
1	Unpack your Device	
2	Optional: Connect your Scope to the signal output. (SMC jacket)	
3	Connect the serial lines to a PC / PLB-21. The PLCS-40 cannot be used without this	See connector 6, page 5
4	Connect the power supply	See connector 1, page 5
5	Optional: Connect an external trigger source	
6	Power on your device	
7	When the initializing is done, adjust the pulse parameters to your needs. See "Controlling the PLCS-40 using the PLB-21 / PC"	
8	Activate the output	

Operating Modes

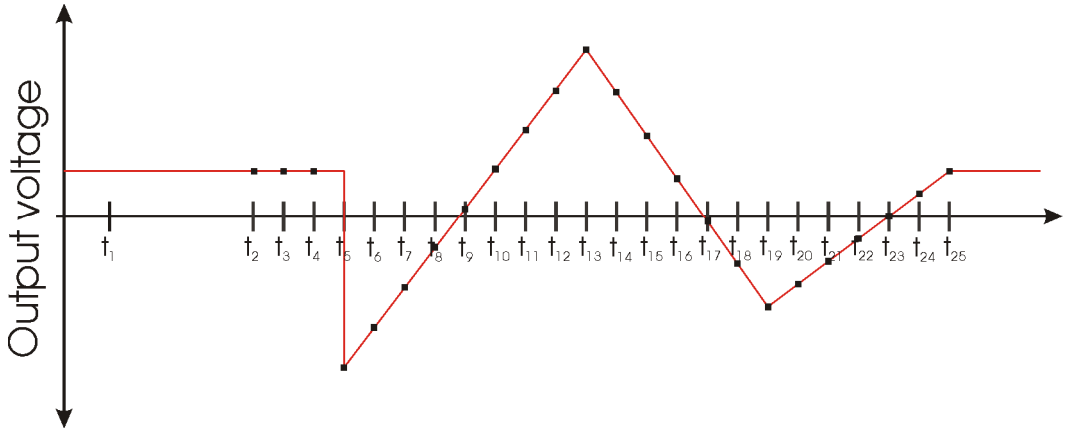
The PLCS-40 can be operated in two different ways: As a digital pulse generator with various trigger functions and as an analogue pulse generator. Both modes are described below: Please note that the PLCS-40 only support rectangular pulse output in digital mode.

Using the PLCS-40 as a Digital Function Generator

The PLCS-40 will automatically put into the digital mode by selecting the appropriate trigger mode in the LSTAT register. The pulse width, repetition rate, number of pulses to be generated and the trigger modes can be controlled via several registers. Please see chapter "Trigger Modes" for more information about the usage of the trigger functions.

Using the PLCS-40 as a Analogue Function Generator

The PLCS-40 will automatically put into the analogue mode by selecting the appropriate trigger mode in the LSTAT register. The pulse width can be controlled in steps of 5ns to a maximum of 320ns. Each step needs two 16-Bit data words as the DAC is updated every 2.5ns. Hence, to generate a complete pulse of 320ns width 128 data words need to be programmed. The following diagram shows a pulse example:



Pulse output stage

The schematic of output circuit is shown in Figure 2. The output amplifier will generate a square-wave signal with an amplitude of 6,6V. If a 50 Ohm load is attached to connectors 2, 3, or 4 this will result in a signal level of 3.3V at the load. Unlike the trigger inputs the output circuit is not galvanically isolated from the power supply. To obtain a well-formed signal a load of 50 Ohm is recommended. Refer to the electrical characteristics on chapter "Electrical Characteristics" for further details.

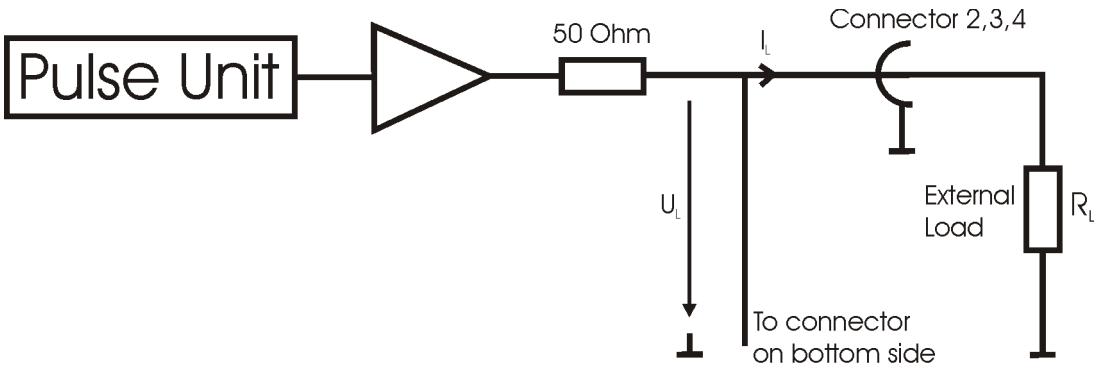


Figure 2: Pulse output circuit

Trigger Modes

The PLCS-40 supports a number of trigger modes which are described below. These does only affect the digital function generator. The width and repetition rate of the pulses generated are user defined. Pulses will always be generated as long as the trigger condition matches and the laser is enabled.
As an input for the trigger signal the connector 5 or the upper pin header can be used. Figure 3 shows the schematic of both inputs. Note that they are galvanically isolated from the supply voltage. For trigger levels see the electrical characteristics on chapter "Electrical Characteristics".

> **Important:** Never use both trigger inputs at the same time. Correct operation is not ensured if both inputs are connected to a source. Furthermore, a signal fed into one input may result in a current flowing out of the other input. This might damage your trigger source.

In the following the different trigger modes are described separately:

Edge

In this mode an external trigger source is required to generate pulses. The pulses can either be generated on the rising or the falling edge of the supplied trigger. On each edge which equates the given setting, a given number of pulses ("Shots") will be generated.

Pulse

In this mode an external trigger source is required to generate pulses. The PLCS will generate pulses during the positive or negative part of the trigger source.

Internal

In this mode the external trigger source is ignored. The PLCS will generate an infinite number of pulses by itself.

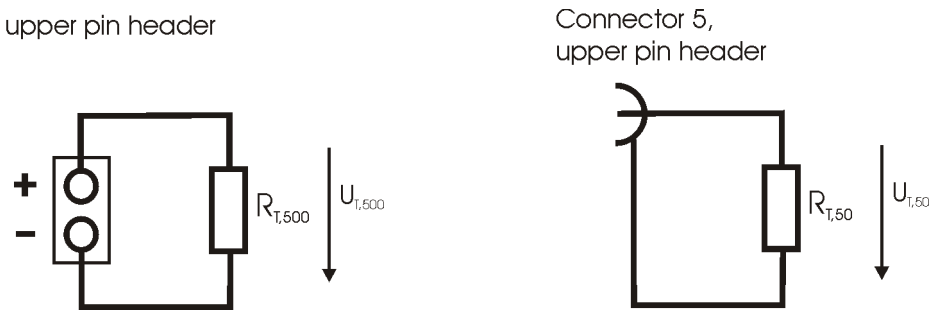


Figure 3: Trigger input circuit

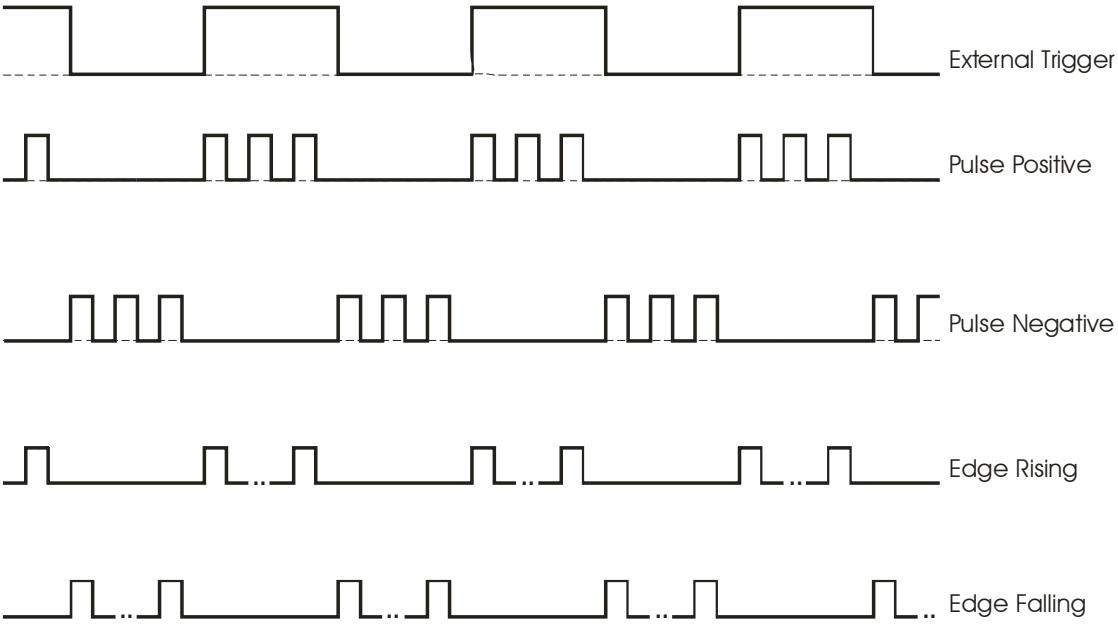


Figure 4: Schematic pulse diagram

Pulse Jitter

The following table shows the typical jitter values for the pulse to pulse and the pulse length jitter. These are identical for all trigger modes as the pulses are generated the same way.

	typ. jitter
pulse to pulse	250ps
pulse length	250ps

External Trigger Delay

The following table shows the typical delay times between a trigger event on the external trigger input and the response on the pulse output.

trigger mode	**typical delay**
pulse, negative	175ns
pulse, positive	86ns
edge, negative	175ns
edge, positive	86ns
dac	40-45ns

12-bit ADC

The PLCS-40 is equipped with four 12-bit ADC channels. These can be read out by the user using the PLB-21 or the appropriate serial commands. The ADC input pins are protected by clamping diodes in order to provide ESD protection.
The PLCS-40 uses its internal +3,3 V supply and the system ground as analogue reference points. The +3,3 voltage is available on an external pin, but must not stressed with more than a few milliamperes.

16-bit DAC

The PLCS-40 is equipped with a additional four channel 16-bit digital to analogue converter which is accessible by the user. The +3,3 V supply and the system ground as analogue reference points. The +3,3 voltage is available on an external pin, but must not stressed with more than a few milliamperes.

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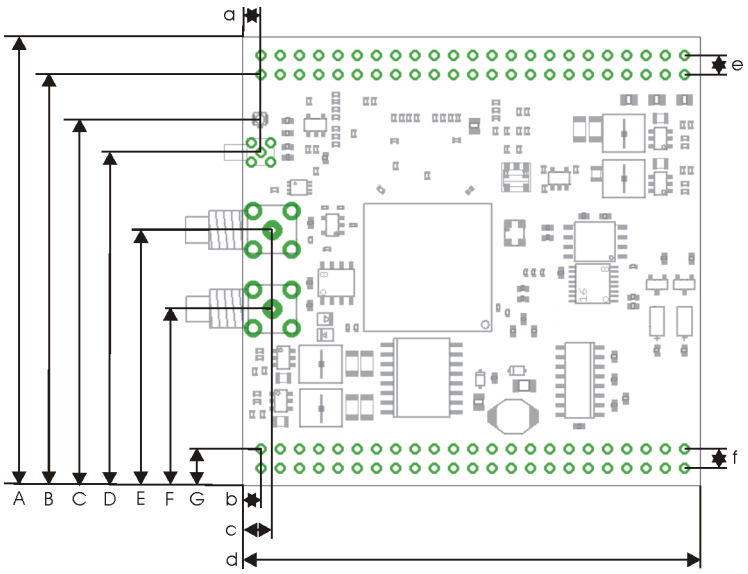
Mechanical Dimensions

The following dimensions are in millimetres (mm).



A	59,2
B	54,3
C	48,3
D	44
E	33,8
F	23,3
G	4,9

a	2,4
b	2,4
c	3,9
d	60,4
e	2,54
f	2,54

Controlling the PLCS-40 Using a PLB-21

To control the PLCS-21 with a PLB-21 it must be connected via the enclosed cable. The PLB-21 will not work if both, the USB and the PLB-21, are connected the same time.
When the PLB-21 is connected the first time to a PLCS-21 you are asked to download a new driver. This must be confirmed with "yes" for the PLB-21 to work properly.

Menu Structure

The following diagram shows the structure of the PLB-21 menu which affects the PLCS-21. All entrys are described in detail. All other menu entries are described in the PLB-21 manual. For detailed instructions see the PLB-21 manual.

Menu root

- Pulseparameter
  - Width
  - Reprate
- Trigger
  - Mode
  - Logic
  - Shots
- Analogue
  - Form
  - Length
  - Delay
- Data
  - Form
  - Pos
  - Value
- Adc
  - Vcc
  - Cho
  - Ch1
  - Ch2
  - Ch3
- Dac
  - DAC Cho
  - DAC Ch1
  - DAC Ch2
  - DAC Ch3
- Temperature
  - Dev. Off
  - Dev. Max
  - Dev. Act
  - PLCS Act.

Pulseparameter

In this menu point you can modify the pulse length and repetition rate. Please note that these values are not used in every trigger mode.

Width
This value defines the pulse width in nano seconds (ns). The minimum and maximum values are defined by the actual repetition rate.

Reprate
This value defines the repetition rate in Hertz (Hz). The actual minimum and maximum values depend on the given pulse width.

Trigger

The PLCS-40 supports a number of trigger modes. For a detailed description of each mode see chapter "Trigger modes".

Mode
This selects the used trigger mode.

Logic
This option is only used when the trigger mode is either "edge" or "pulse". In "edge" mode you can select if pulses should be generated on the rising or falling edge of the supplied trigger. In "pulse" mode it selects weather pulses should be generated on "positive" (high) or the "negative" (low) part of the trigger signal.

Shots
When using the edge mode, the number of generated pulses can be determined by the user. The given number of pulses will always be generated, even if another trigger is received during generation.

Analogue

The PLCS-40 supports the generation or analogue pulse forms. This is configured in this submenu

Form
This selects the used analogue pulse form data storage. See chapter "Analogue pulse generation" for more information.

Length
This selects the length of the generated analogue pulse. See chapter "Analogue pulse generation" for more information.

Delay
This selects the delay of the generated analogue pulse. See chapter "Analogue pulse generation" for more information.

Data

The PLCS-40 supports the generation or analogue pulse forms. The required data can be altered within this submenu.

Form
This selects the analogue pulse form which should be altered.

Pos
This selects the data field which should be altered.

Value
This shows and alters the selected data field.

Adc

The PLCS-40 is equipped with several ADC channels. These can be monitored here

Vcc
This value shows the current supply voltage.

Ch 0 … 3
This value shows the current ADC value of the desired channel. Please see chapter "ADC " for more information.

Dac

The PLCS-40 is equipped with four 16-bit DAC channels. These can be set here.

DAC Ch 0 … 3
This value selects the DAC output value. Please see chapter "DAC" for more information.

Temperature

The PLCS-40 is equipped with an onboard NTC sensor to monitor the PCB temperature. This can be done here

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Controlling the PLCS-40 via PC

Introduction

In addition to being able to connect up a PLB-21, the PLCS-40 can also communicate with a computer/laptop. This interface allows communications over both a serial text interface as well as using the PicoLAS protocol. While the text interface is designed for communication with a terminal program, the PicoLAS protocol is designed as a system interact protocol.

The switching between the two protocols occurs automatically as soon as the PLCS-40 receives a certain sequence. The corresponding commands are:

- PING for the PicoLAS protocol
- "init" followed by <Enter> for the text interface

Description of the Serial Interface

The PLCS-40 implements a standard RS232 serial interface. A simple 3-wire connection is required for the communication. The connection settings are:

Baud rate	115200
Data bits	8
Stop bits	1
Parity	even

The Serial Text Interface

The following section describes the structure and commands of the text interface.

Structure

Every command that is sent to the PLCS-40 must be completed with a CR (Enter). It consists of a command word followed by a parameter. If the command was successfully executed then an "0" is sent, otherwise a "1". If the command requires an answer parameter, this parameter is sent before the confirmation is given.

Example:

The user would like to read out the voltage currently being used by the pulser.

User input: ghwver<Enter>

Output of the PLCS-21: 1.0.0

0

Input is done in ASCII code and is case sensitive. Every terminal can be used that supports this standard.

Commands for the PLCS-40

The following table contains a command reference for the PLCS-40.

Command	Parameter	Answer	Description
help	--	Help text	Returns of a help text
ghwver	--	Hardware version	Returns a hardware version string
gswver	--	Software version	Returns a software version string
gserial	--	serial number	Returns the device serial number
gname	--	device name	Returns the device name
ps	--	current settings	Prints out the current device settings
loaddef	--	--	Load previously saved default values
savedef	--	--	Save current settings as default values
gerrtxt	--	Error text	Returns the content of the ERROR register in readable form
gerr	--	ERROR register	Returns the content of the ERROR register
clrerr	--	--	Clears any pending error condition
glstat	--	LSTAT register	Returns the content of the ERROR register
slstat	number	LSTAT register	Sets the LSTAT register to the given value

Command	Parameter	Answer	Description
lon	--	--	Enables the pulse output
loff	--	--	Disables the pulse output
enautodef	--	--	Enables the automatic loading of the defaults values every start-up
disautodef	--	--	Disables the automatic loading of the defaults values every start-up
strgmode	trigger mode	trigger mode	Sets the trigger mode to the given value. See chapter trigger modes.
gtrgmode	--	trigger mode	Returns the current trigger mode
gado	--	ADC value	Returns the ADC value of channel 0
gad1	--	ADC value	Returns the ADC value of channel 1
gad2	--	ADC value	Returns the ADC value of channel 2
gad3	--	ADC value	Returns the ADC value of channel 3
gaduin	--	Supply voltage	Returns the current supply voltage
gdao	--	DAC value	Returns the current DAC value of channel 0
gda1	--	DAC value	Returns the current DAC value of channel 1
gda2	--	DAC value	Returns the current DAC value of channel 2
gda3	--	DAC value	Returns the current DAC value of channel 3
sdao	DAC value	DAC value	Sets the DAC channel 0 to the given value. Returns the new DAC value.
sda1	DAC value	DAC value	Sets the DAC channel 1 to the given value. Returns the new DAC value.
sda2	DAC value	DAC value	Sets the DAC channel 2 to the given value. Returns the new DAC value.
sda3	DAC value	DAC value	Sets the DAC channel 3 to the given value. Returns the new DAC value.
gdamin	--	minimal DAC value	Returns the minimal possible DAC value
gdamax	--	maximal DAC value	Returns the maximal possible DAC value

Command	Parameter	Answer	Description
gwidth	--	current pulse width	Returns the current pulse width
gwidthmin	--	minimal possible pulse width	Returns the minimal possible pulse width
gwidthmax	--	maximal possible pulse width	Returns the maximal possible pulse width
swidth	pulse width	pulse width	Sets the pulse width to the given value. The new pulse width is returned.
greprate	--	current repetition rate	Returns the current repetition rate
grepratemin	--	minimal possible repetition rate	Returns the minimal possible repetition rate
grepratemax	--	maximal possible repetition rate	Returns the maximal possible repetition rate
sreprate	repetition rate	repetition rate	Sets the repetition rate to the given value. The new pulse width is returned.
gcount	--	number of pulses	Returns the configured number of pulses, that should be generated on every trigger
gcountmin	--	minimal number of pulses	Returns the minimal number of pulses, that can be generated on every trigger
gcountmax	--	maximal number of pulses	Returns the maximum number of pulses, that can be generated on every trigger
scount	number of pulses	number of pulses	Sets the number of pulses that should be generated on every trigger to the given value. The new number is returned.
gtemp	--	PCB temperature	Returns the actual PCB temperature
gtempmax	--	maximum PCB temperature	Returns the maximum PCB temperature before shutdown
gform	--	puls form number	Returns the actual puls form number
gformcnt	--	number of possible puls forms	Returns the number of different puls forms
sform	puls form number	puls form number	Sets the puls form set point to the given number. The new selected puls form is returned

Command	Parameter	Answer	Description
gdelay	--	delay	Returns the configured DAC output delay
gdelaymin	--	minimum delay	Returns the minimum possible delay value
gdelaymax	--	maximum delay	Returns the maximum possible delay value
sdelay	delay	delay	Sets the DAC output delay to the given value. The new delay value is returned
glength	--	DAC puls length	Returns the actual configured DAC puls length
glengthmin	--	minimum DAC puls length	Returns minimum possible DAC puls length
glengthmax	--	maximum DAC puls length	Returns maximum possible DAC puls length
gdata	<form> <pos>	data value	Returns the data value of the given form and position.
gdatamin	--	minimal valid data value	Returns the minimal valid data value
gdatamax	--	maximal valid data value	Returns the maximal valid data value
sdata	<form> <pos> <data>	data value	Sets the data of the given form and position to the given value. The new data value is returned

If an Error Occurs

If an error occurs during operation the pulse output is switched off and a message is sent to the terminal. Errors have to be acknowledged with "clrerror" otherwise switching on again of pulse output is not possible. Note that warnings are also displayed this way but these do not switch off pulse output. Hence it is not necessary to aknowledge warnings with "clrerror".
This message has this format:

err: <Error Register>

The parameter <Error Register> represents the content of the ERROR register in binary form.

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The PicoLAS Protocol

The following section describes the structure and possible commands of the PicoLAS protocol.

Structure

Each transmission consists of 12 bytes – called a frame as follows – which must be sent consecutively. Otherwise the system times out and the transmission must start again from the beginning.

A frame has a fixed structure. The first two bytes describe the command, the following eight bytes the parameters, followed by one reserved byte and one checksum byte. The checksum is calculated out of the first 11 bytes which are linked by a bitwise XOR.

Thus a frame has the following structure:

Byte	Meaning
1	Bit 8-15 of the command
2	Bit 0-7 of the command
3	Bit 56-63 of the parameter
4	Bit 48-55 of the parameter
5	Bit 40-47 of the parameter
6	Bit 32-39 of the parameter
7	Bit 24-31 of the parameter
8	Bit 16-23 of the parameter
9	Bit 8-15 of the parameter
10	Bit 0-7 of the parameter
11	Reserved, always 0x00
12	Checksum

A properly received frame must be acknowledged by the recipient with an answer, which is also a frame. If the acknowledgement does not occur then the command has not been processed and the sending procedure should be repeated.

If the recipient recognizes the command as valid, but not the parameters, then it will answer with a ILGLPARAM (0xFF12) as command.

In the case that the recipient receives an invalid command it will answer with UNCOM (0xFF13).

If a faulty checksum is recognized then the answer is RXERROR (0xFF10). If this error occurs often then the connection should be checked.

Using the REPEAT (0xFF11) command the recipient can instruct the sender to send the most recent frame again.

General Commands

The following list contains an overview of the general commands which are supported by every product from PicoLAS which makes use of this protocol. The explanation of the individual commands is given further below.

Command Name	Sent Frame		Answer Frame	
	Command	Parameter	Command	Parameter
PING	0xFE01	0	0xFF01	0
IDENT	0xFE02	0	0xFF02	ID
GETHARDVER	0xFE06	0	0xFF06	Version
GETSOFTVER	0xFE07	0	0xFF07	Version
GETSERIAL	0xFE08	0 ... 255	0xFF08	Refer to description
GETIDSTRING	0xFE09	0 ... 255	0xFF09	Refer to description
GETDEVICECHECKSUM	0xFE0A	0	0xFF0A	CRC16 checksum
RESET	0xFE0E	0	0xFF0B	0

PING
Is used to determine the presence of a connected recipient and to initialize the interface of the recipient for this protocol. Has no effect on the condition of the recipient. The command parameter is always 0, the answer parameter too.

IDENT
It is used to determine the device ID of an attached recipient. Has no effect on the condition of the recipient. The parameter is always 0. The answer contains the ID.

GETHARDVER
Instructs the recipient to send back the version number of the hardware being used. The parameter is always 0. The answer contains the hardware version of the recipient. The format of the answer is: 0x0000000<major><minor><revision>. In other words, one byte for each of the three elements of the version number.
As example, version 1.2.3 has the parameter 0x000000010203.

GETSOFTVER
Instructs the recipient to send back the version number of the software being used. The parameter is always 0.
The answer contains the software version of the recipient. The format of the answer is: 0x0000000<major><minor><revision>. In other words, one byte for each of the three elements of the version number.
As example, version 2.3.4 has the parameter 0x000000020304.

GETSERIAL
Instructs the recipient to send back its serial number. If 0 is sent as parameter, the answer contains the number of (ASCII) digits of the serial number; otherwise the respective position of the serial number is sent in ASCII format.

GETIDSTRING
Instructs the recipient to send back the name of the device. If 0 is sent as parameter, the answer contains the number of digits of the string, otherwise the respective position of the serial number is sent in ASCII format.

GETDEVICECHECKSUM
Instructs the recipient to transmit a CRC16 checksum of its memory. This can be used to check the integrity of the programme memory after switching on.

RESET
Instructs the recipient to carry out a software reset. This resets the device to the switch-on state. The parameter is always 0.

Commands for the PLCS-40

The following table contains a list of the commands which the PLCS-21 supports in addition to the generally applicable commands. An explanation of the individual commands follows afterwards.

Command	Sent Frame		Received Frame	
	Command	Parameter	Command	Parameter
GETLSTAT	0x0010	0	0x0110	LSTAT register
SETLSTAT	0x0011	LSTAT register	0x0110	LSTAT register
GETERROR	0x0020	0	0x0120	ERROR register
CLEARERROR	0x0021	0	0x0120	0
GETWIDTH	0x0030	0	0x0130	pulse width in ns
GETWIDTHMIN	0x0031	0	0x0130	pulse width in ns
GETWIDTHMAX	0x0032	0	0x0130	pulse width in ns
GETWIDTHSTEPSIZE	0c0033	0	0x0130	size of one pulse width step
SETWIDTH	0x0034	pulse width in ns	0x0130	pulse width in ns
GETREPRATE	0x0035	0	0x0130	reprate in Hz
GETREPRATEMIN	0x0036	0	0x0130	reprate in Hz
GETREPRATEMAX	0x0037	0	0x0130	reprate in Hz
GETREPRATESTEPSIZE	0x0038	0	0x0130	size of one reprate step
SETREPRATE	0x0039	reprate in Hz	0x0130	reprate in Hz
GETCOUNT	0x003A	0	0x0130	number of pulses
GETCOUNTMIN	0x003B	0	0x0130	number of pulses
GETCOUNTMAX	0x003C	0	0x0130	number of pulses
GETCOUNTSTEPSIZE	0x003D	0	0x0130	size of one number step
SETCOUNT	0x003E	number of pulses	0x0130	number of pulses
GETPULSFORM	0x040	0	0x0140	current selected puls-form

Command	Sent Frame		Received Frame	
	Command	Parameter	Command	Parameter
GETPULSFORMCOUNT	0x0041	0	0x0140	number of pulse forms
SETPULSFOM	0x0042	pulse form	0x0140	pulse form
GETPULSDELAY	0x0043	0	0x0140	delay
GETPULSDELAYMIN	0x0044	0	0x0140	minimal delay
GETPULSFORMMAX	0x0045	0	0x0140	maximal delay
SETPULSDELAY	0x0046	delay	0x0140	delay
GETPULSLENGTH	0x0047	0	0x0140	pulse length
GETPULSLENGTHMIN	0x0048	0	0x0140	minimal pulse length
GETPULSLENGTHMAX	0x0049	0	0x0140	maximal pulse length
SETPULSLENGTH	0x004A	pulse length	0x0140	pulse length
GETPULSFORMDATA	0x004B	see text	0x0140	pulse form data
SETPULSFORMDATA	0x004C	see text	0x0140	pulse form data
GETPULSFORMDATAMIN	0x004D	0	0x0140	minimal valid data value
GETPULSFORMDATAMAX	0x004E	0	0x0140	maximal valid data value
GETPULSFORMDATACOUNT	0x004F	0	0x0140	number of data fields
LOADEFAULTS	0x0050	0	0x0150	load default values
SAVEDEFAULTS	0x0051	0	0x0150	save default values
GETTEMP	0x0060	0	0x0160	PCB temperature
GETTEMPWARN	0x0061	0	0x0160	temp. warning border
GETTEMPMAX	0x0062	0	0x0160	temp. shutdown border
GETDAC0	0x00B0	0	0x01B0	DAC channel 0 value
SETDAC0	0x00B1	DAC value	0x01B0	DAC channel 0 value
GETDAC1	0x00B2	0	0x01B0	DAC channel 1 value
SETDAC1	0x00B3	DAC value	0x01B0	DAC channel 1 value
GETDAC2	0x00B4	0	0x01B0	DAC channel 2 value
SETDAC2	0x00B5	DAC value	0x01B0	DAC channel 2 value
GETDAC3	0x00B6	0	0x01B0	DAC channel 3 value
SETDAC3	0x00B7	DAC value	0x01B0	DAC channel 3 value
GETDAC	0x00B8	0	0x01B0	All four DAC values
GETDACMIN	0x00B9	0	0x01B0	minimal DAC value
GETDACMAX	0x00BA	0	0x01B0	maximal DAC value
SETDAC	0x00BB	All four DAC values	0x01B0	All four DAC values

Command	Sent Frame		Received Frame	
	Command	Parameter	Command	Parameter
GETADCCH0	0x00C0	0	0x01C0	ADC value channel 0
GETADCCH1	0x00C1	0	0x01C0	ADC value channel 1
GETADCCH2	0x00C2	0	0x01C0	ADC value channel 2
GETADCCH3	0x00C3	0	0x01C0	ADC value channel 3
GETADC	0x00C4	0	0x01C0	All four ADC values
GETADCUIN	0x00C5	0	0x01C0	Supply voltage

Description of the Individual Commands

GETLSTAT
This command returns the value of the LSTAT register. For a complete description of this register see below.

SETLSTAT
This command sets the LSTAT register to the given value. The return value contains the new register value.

GETERROR
This command returns the value of the ERROR register. For a complete description of this register see below.

CLEARERROR
This command clears a part of the internal ERROR register. For a detailed description of the ERROR register see below.

GETWIDTH
Returns the current pulse width of the internal pulse generator in [ns].

GETWIDTHMIN
Returns the minimum possible pulse width of the internal pulse generator. The value is measured in [ns].

GETWIDTHMAX
Returns the maximum possible pulse width of the internal pulse generator. This value depends of the current repetition rate. Hence, any change in the repetition rate changes this value too. It is measured in [ns].

SETWIDTH
Sets the pulse width of the internal pulse generator to the given value. It must be within the borders defined by GETWIDTHMIN and GETWIDTHMAX. The value is measured in [ns].

GETREPRATE
Returns the actual repetition rate of the internal pulse generator. The value is measured in [Hz].

GETREPRATEMIN
Returns the minimum possible repetition rate of the internal pulse generator. The value is measured in [Hz].

GETREPRATEMAX
Returns the maximum possible repetition rate of the internal pulse generator. This value depends of the current pulse width. Hence, any change in the pulse width changes this value too. It is measured in [Hz].

SETREPRATE
Sets the repetition rate of the internal pulse generator to the given value. It must be within the borders defined by GETREPRATEMIN and GETREPRATEMAX. The value is measured in [Hz].

GETCOUNT
Returns the number of pulses the internal pulse generator will generate as soon as it becomes enabled. This is only used if the counting mode is enabled. See chapter "trigger modes" for more information.

GETCOUNTMIN
Returns the minimal number of pulses the pulse generator can produce if counting mode is enabled.

GETCOUNTMAX
Returns the maximal number of pulses the pulse generator can produce if counting mode is enabled.

SETCOUNT
Sets the number of pulses the pulse generator will generate to the given value. It must be within the borders defined by GETCOUNTMIN and GETCOUNTMAX.

GETPULSFORM
Returns the actual selected pulse form of the analogue pulse generator.

GETPULSFORMCOUNT
Returns the available number of different pulse forms.

SETPULSFORM
Sets the set point pulse form of the analogue pulse generator to the given value. This value must not be greater than the return value of the GETPULSFORMCOUNT command.

GETPULSDELAY
Returns the actual configured delay of the analogue pulse generator.

GETPULSDELAYMIN
Returns the minimal available pulse delay value for the analogue pulse generator.

GETPULSDELAYMAX
Returns the maximal available pulse delay value for the analogue pulse generator.

SETPULSDELAY
Sets the pulse delay of the analogue pulse generator to the given value. This value must within the border defined by the GETPULSDELAYMIN and GETPULSDELAYMAX command.

GETPULSLENGTH
Returns the actual configured length of the analogue pulse generator. This value is measured in steps of 5 ns.

GETPULSLENGTHMIN
Returns the minimal available pulse length for the analogue pulse generator.

GETPULSLENGTHMAX
Returns the maximal available pulse length for the analogue pulse generator.

GETPULSFORMDATA
Returns the data value of the given pulse form and position within the pulse form. The lower 16bit of the parameter must contain the position while the next 16bit must contain the pulse form number. The answer contains a 32-bit signed integer which represents the data value.

GETPULSFORMDATAMIN
Returns the minimal valid data value for any pulse form. The value is a 32-bit signed integer.

GETPULSFORMDATAMAX
Returns the maximal valid data value for any pulse form. The value is a 32-bit signed integer.

SETPULSFORMDATA
Sets the data field of the given pulse form and position to the given value. This value must within the border defined by the GETPULSFORMDATAMIN and GETPULSFORMDATAMAX command. The parameter must contain the data value in the lower 32-bit (signed integer), the position in the bits 32 ... 47 and the pulse form in the bits 48 ... 63.

LOADDEFAULTS
This command replaces all internal parameters with their default values. If the output is enabled during the execution of this command, the L_ON bit of the LSTAT register will be cleared and the output disabled. This command will fail if the CRC_DEFAULT_FAIL bit in the ERROR register I set, indicating an error within the data.
If the DEF_PWRON bit in the LSTAT register is set, the device automatically loads these values during power-up.

SAVEDEFAULTS
This command saves all internal parameters into an EEPROM for later usage. Use command LOADDEFAULTS to restore them.

GETTEMP
Returns the actual measured PCB temperature. The value is represented in a 16bit signed integer and measured in 0.1°C

GETTEMPWARN
Returns the temperature at which the device indicates a temperature warning in the ERROR register. The value is represented in a 16bit signed integer and measured in 0.1°C

GETTEMPMAX
Returns the temperature at which the device indicates a temperature error in the ERROR register. The value is represented in a 16bit signed integer and measured in 0.1°C

GETDAC0
Returns the actual configured output value of the 16-bit DAC channel 0.

SETDAC0
Sets the output value of the 16-bit DAC channel 0 to the given value. The value must be within the borders defined by the GETDACMIN and GETDACMAX commands.

GETDAC1
Returns the actual configured output value of the 16-bit DAC channel 1.

SETDAC1
Sets the output value of the 16-bit DAC channel 1 to the given value. The value must be within the borders defined by the GETDACMIN and GETDACMAX commands.

GETDAC2
Returns the actual configured output value of the 16-bit DAC channel 2.

SETDAC2
Sets the output value of the 16-bit DAC channel 2 to the given value. The value must be within the borders defined by the GETDACMIN and GETDACMAX commands.

GETDAC3
Returns the actual configured output value of the 16-bit DAC channel 3.

SETDAC3
Sets the output value of the 16-bit DAC channel 3 to the given value. The value must be within the borders defined by the GETDACMIN and GETDACMAX commands.

GETDAC
Returns the actual configured output values of all four DAC channels in one parameter. The lower 16-bit of the answer parameter contains the DAC channel 0, the next 16-bit the DAC channel 1 and so on.

GETDACMIN
Returns the minimum valid value for any DAC channel.

GETDACMAX
Returns the maximum valid value for any DAC channel.

GETADC0
Returns the actual measured value of ADC channel 0. The value is within [0 ... 4095]

GETADC1
Returns the actual measured value of ADC channel 1. The value is within [0 ... 4095]

GETADC2
Returns the actual measured value of ADC channel 2. The value is within [0 ... 4095]

GETADC3
Returns the actual measured value of ADC channel 3. The value is within [0 ... 4095]

GETADC0
Returns the actual measured value of all four ADC channels in one answer parameter. The lower 16-bit of the answer parameter contains the ADC channel 0, the next 16-bit the ADC channel 1 and so on.

GETADCUIN
Returns the actual measured supply voltage. The answer is measured in 0.1 V.

Description of the LSTAT Register

The following list contains a description of the individual LSTAT bits. These can be read with GETLSTAT and written with SETLSTAT. With SETLSTAT a complete 32 bit word must always be written. Thus, to change individual bits, first the register must be read out with GETLSTAT, then the desired bits changed and then with SETLSTAT passed again to the PLCS.

Bit	Name	Read/Write	Meaning
0	L_ON	Read/write	Switch on/off the pulse output
1-4	TRG_MODE	Read/write	Refer to trigger modes 0 = positive edge trigger 1 = negative edge trigger 2 = internal trigger 3 = not valid -> automatically set to 2 4 = positive pulse trigger 5 = negative pulse trigger 6 = analogue pulse genetation
5	DEF_PWRON	Read/write	Indicates weather the defaults are loaded on power-up
6	PULSER_OK	Read	When "0", the device in an error condition
7-31	Reserved	Read	Reserved

Description of the ERROR Register

The following list contains a description of the individual bits of the ERROR register.

Bit	Name	Read/Write	Meaning
0	CRC_DEVDRV_FAIL	read only	A CRC error was detected in the PLB driver. The driver cannot be used. This does not affect the device but the PLB.
1	CRC_DEFAULT_FAIL	read only	A CRC error was detected in the default values. A re-save of the values should correct this.
2	CRC_CONFIG_FAIL	read only	A CRC error was detected in the internal configuration values. Please contact your distributor.
3	reserved	read only	reserved
4	reserved	read only	reserved
5	VCC_FAIL	read only	The supply voltage is too low or too high
6	I2C_FAIL	read only	Internal I²C error. If error persists, please contact your distributor.
7	FAILED_TO_LOAD_DEFAULTS	read only	The loading of the default failed. Normally this is because of an pending CRC error.
8	TEMP_OVERSTEPPED	read only	The internal temperature was beyond safe operating limits.
9	TEMP_WARNING	read only	The internal temperature is 5°C before shutdown.
10	FPGA_FAIL	read only	Internal initialisation failure. If error persists, please contact your distributor
11-31	Reserved	Read	Reserved

If a critical error occurs pulser emissions stop automatically. All error situations must be acknowledged or reset with CLRERROR. Otherwise the PLCS cannot restart pulse output.

Example Implementation in MS Visual Basic

The following is a possible implementation of the protocol for uni-directional communications in MS Visual Basic. No guarantee of functionality is assumed.

```
Public Class Protocol
    Public Const PING As UShort = &HFE01
    Public Const IDENT As UShort = &HFE02
    Public Const GETHARDVER As UShort = &HFE06
    Public Const GETSOFTVER As UShort = &HFE07
    Public Const GETSERIAL As UShort = &HFE08
    Public Const GETIDSTRING As UShort = &HFE09
    Public Const GETDEVICECHECKSUM As UShort = &HFE0B
    Public Const RESET As UShort = &HFE0E
    Public Const ACK As UShort = &HFF01
    Public Const IDACK As UShort = &HFF02
    Public Const VERSIONACK As UShort = &HFF03
    Public Const HARDVERACK As UShort = &HFF06
    Public Const SOFTVERACK As UShort = &HFF07
    Public Const SERIALACK As UShort = &HFF08
    Public Const IDSTRINGACK As UShort = &HFF09
    Public Const CHECKSUMACK As UShort = &HFF0A
    Public Const RESETACK As UShort = &HFF0B
    Public Const RXERROR As UShort = &HFF10
    Public Const REPEAT As UShort = &HFF11
    Public Const ILGLPARAM As UShort = &HFF12
    Public Const UNCOM As UShort = &HFF13

    Private RecParameter As UInt64 = 0
    Private RecAnswer As UInt64 = 0
    Private Comport As String = ""
    Private PortOpen As Boolean = False
    Private Serial As IO.Ports.SerialPort = Nothing
    Private IamBusy As Boolean = False

    Public Function GetAnswer() As UShort
        Return RecAnswer
    End Function

    Public Function GetParameter() As UInt64
        Return RecParameter
    End Function

    Property Status() As Integer
        Get
            Return PortOpen
        End Get
        Set(ByVal Value As Integer)

        End Set
    End Property

    Property Busy() As Integer
        Get
            Return IamBusy
        End Get
        Set(ByVal Value As Integer)
        End Set
    End Property

    Public Function Enable(ByVal port As String) As Boolean
        If (PortOpen) Then
            Return True
        End If
```

```
        Try

            If (Not (port = "")) Then
                Comport = port
            End If
            Serial = New IO.Ports.SerialPort(Comport, 115200,
IO.Ports.Parity.Even, 8, IO.Ports.StopBits.One)
            Serial.Open()
            PortOpen = True

            SendReceive(Me.PING, 0, Me.ACK)
            SendReceive(Me.PING, 0, Me.ACK)

        Catch ex As Exception

            PortOpen = False
            Return False

        End Try

        Return True
    End Function

    Public Function Disable() As Boolean
        If (PortOpen) Then
            Try
                Serial.Close()

            Catch ex As Exception

            End Try

            PortOpen = False
            Serial = Nothing

            Return True

        End If

        Return False
    End Function

    Public Function SendReceive(ByVal command As UShort, ByVal param As UInt64,
ByVal expectet_answer As UShort) As Boolean

        Dim Timeout As UInt32 = 10000
        Dim buffer(12) As Byte

        If (Not PortOpen) Then
            Return False
        End If

        If (IamBusy) Then
            Do
                Application.DoEvents()
            Loop While IamBusy = True
        End If
```

```
        IamBusy = True

        For i As UInteger = 0 To 4
            Timeout = 10000

            Serial.DiscardInBuffer()

            Send(command, param)

            Do
                Timeout -= 1
                Application.DoEvents()
            Loop Until ((Serial.BytesToRead() >= 12) Or (Timeout = 0))

            If (Timeout > 0) Then

                If (Serial.BytesToRead() >= 12) Then

                    If (Receive(buffer)) Then
                        RecAnswer = buffer(0)
                        RecAnswer += Convert.ToUInt16(buffer(1)) << 8
                        RecParameter = buffer(2)
                        RecParameter += Convert.ToUInt64(buffer(3)) << 8
                        RecParameter += Convert.ToUInt64(buffer(4)) << 16
                        RecParameter += Convert.ToUInt64(buffer(5)) << 24
                        RecParameter += Convert.ToUInt64(buffer(6)) << 32
                        RecParameter += Convert.ToUInt64(buffer(7)) << 40
                        RecParameter += Convert.ToUInt64(buffer(8)) << 48
                        RecParameter += Convert.ToUInt64(buffer(9)) << 56
                        IamBusy = False

                        Return (RecAnswer = expectet_answer)
                    End If

                End If

            End If

        Next
        IamBusy = False

        Return False

    End Function

    Private Function Send(ByVal command As UShort, ByVal param As UInt64) As
Boolean

        Dim buffer(12) As Byte

        buffer(0) = command And &HFF
        buffer(1) = (command >> 8) And &HFF
        buffer(2) = param And &HFF
        buffer(3) = (param >> 8) And &HFF
        buffer(4) = (param >> 16) And &HFF
        buffer(5) = (param >> 24) And &HFF
        buffer(6) = (param >> 32) And &HFF
        buffer(7) = (param >> 40) And &HFF
        buffer(8) = (param >> 48) And &HFF
        buffer(9) = (param >> 56) And &HFF
        buffer(10) = 0
```

```
        buffer(11) = CheckByte(buffer)

        WriteByte(buffer)

    End Function

    Private Function Receive(ByVal buffer() As Byte) As Boolean

        For i As UInteger = 0 To 11 Step 1
            buffer(i) = ReadByte()
        Next

        If (buffer(11) = CheckByte(buffer)) Then
            Return True
        End If

        Return False

    End Function

    Private Function CheckByte(ByVal buffer() As Byte) As Byte
        Dim returnvalue As Byte = 0

        For i As UInteger = 0 To 10 Step 1
            returnvalue = returnvalue Xor buffer(i)
        Next

        Return returnvalue
    End Function

    Private Sub WriteByte(ByVal zeichen() As Byte)
        Serial.Write(zeichen, 0, 12)
    End Sub

    Private Function ReadByte() As Byte
        Return Serial.ReadByte()
    End Function

End Class
```

Using this example code, a connection can be set up using the following lines of code:

```
Dim MyProto As Protocol = New Protocol()

MyProto.Enable(„Com3“)

MyProto.SendReceive(Protocol.PING, 0, Protocol.ACK)
```

Electrical Characteristics

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply current		U_S=15V, no cable/device connected to PLCS-40		270		mA
Load resistance (con. 2-4)	R_L		10	50		Ohm
Output voltage (con. 2-4)	U_L	R_L=50 Ohm	2,8	3	3,3	V
Input resistance (con. 5)	$R_{T,50}$		48	50	52	Ohm
Input resistance (accessible trough con 1)	$R_{T,500}$		485		515	Ohm
Low Level input Voltage (con. 5)	$U_{T,50}$	U_S=15V			0.5	V
High Level input Voltage (con. 5)	$U_{T,50}$	U_S=15V	0.6	2.3	3.4	V
Low Level input Voltage (accessible trough con 1)	$U_{T,500}$	U_S=15V			0.5	V
High Level input Voltage (accessible trough con 1)	$U_{T,500}$	U_S=15V	0.9	3.5	4.7	V
Digital I/O			0		3.4	V
ADC input			0		3.4	V
ADC resolution				12		bit
DAC output			0		3.3	V
DAC resolution				16		bit

Absolute Maximum Ratings

Parameter (see figures)	Symbol	
Ambient operating temperature		0°C to +55°C
Supply voltage	U_S	-0.3V to +19.0V
Trigger voltage on connector 5	$U_{T,50}$	-6V to +6V
Trigger voltage on connector 1	$U_{T,500}$	-6V to +6V
Load current on connector 2-4	I_L	170mA